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Abstract

This paper contributes to the literature on non-monetary benefits of Vocational Education and Training (VET) by investigating its influence on a firm's innovation process. While an increasing number of studies finds positive effects of VET on innovation in firms, the role that apprentices play in this mechanism has largely been unexplored. To analyze this role, we use the distinction between technological and organizational innovation, two complementary forms of innovation. When investigating the initiators of organizational innovation, to date, research has primarily focused on internal and external change agents at upper echelons. We conceptualize apprentices as hybrid (a combination of internal and external) change agents at lower echelons. We examine how apprentices in the Swiss VET system are key to integrating external knowledge (through school-based education) with internal knowledge (through on-the-job training) and moderating the influence of organizational innovation on technological innovation. Drawing on a sample of 1,240 firms from a representative Swiss Innovation Survey, we show that apprentices leverage the positive association between innovations in a firm's business processes and organization of work with incremental innovations. With the description of a new mechanism that shows the significant role of apprentices on firms' technological innovation activities and evidence for supportive associations between key variables, we contribute to the understanding of the influence of VET on innovation in firms.

Keywords

Hybrid change agents, technological innovation processes, organizational innovation, Vocational Education and Training (VET), apprenticeships

1. Introduction

A constantly growing literature investigates the influence of VET on innovation in firms (e.g., Dalitz and Toner, 2016; Rupietta and Backes-Gellner, 2019a; Backes-Gellner and Pfister 2019; Lewis 2020). While their results show a positive influence of VET on innovation, the ‚generative mechanism of these effects are still not fully uncovered. Dual-track VET consists of theoretical lessons in vocational schools and on-the-job training in a host firm. From a host firm's perspective dual-track VET operates with external and internal knowledge and apprentices integrate this knowledge during their training program. The integration of external knowledge in the internal innovation process can lead to the generation of innovations. The role of apprentices in the innovation process has so far not been at the center of research on VET and innovation, although apprentices integrate innovation-relevant external and internal knowledge during their training. This paper investigates the role of apprentices and analyzes their influence on different forms of innovation such as technological and organizational innovation.

Innovation research has traditionally emphasized technological innovation, i.e., the development of new or improvement of existing technologies, technological products and technical processes (Damanpour, 1996; Walker et al., 2010). More recently, research has increasingly emphasized the importance of better understanding organizational innovation and the complementarities between technological and organizational innovation (Birkinshaw et al., 2008; Tushman et al., 2010) . In contrast to technological innovation, organizational innovation refers to the introduction and development of new organizational practices, processes, or structures[1]. In the past, scholars have frequently argued that firms will benefit more from innovation when introducing multiple streams of innovation simultaneously (Tether and Tajar,

[1] Scholars have used different, albeit related, terms for this non-technological innovation, such as administrative, ancillary, or management innovation (Lam, 2005). We adopt an understanding of organizational innovation that relates to innovation in the elements of the design of an organization (see also Heyden et al., 2015; Vaccaro et al., 2012).

2008; Tushman et al., 2010). Recent empirical evidence, reinforcing earlier theorizing, exposes the importance of complementarities between technological and organizational innovation for firms' competitive advantage.

Thus far, however, the scholarly understanding of how firms may benefit from these innovation complementarities remains underdeveloped. Theories on organizational innovation and how organizational innovation facilitates technological innovation suffer from a number of limitations. First, studies that have explicitly investigated the influence of organizational on technological innovation (e.g., Camisón and Villar-López, 2014) have treated technological innovation primarily as an outcome. Second, while research has focused on internal and external change agents to explain how organizational innovation comes about (e.g., Birkinshaw et al., 2008; Heyden et al., 2015), research on the complementarities of organizational and technological innovation has, thus far, neglected the role of change agents in facilitating innovation complementarities. Change agents are key individuals who proactively create, experiment with, validate, and influence the development and implementation of new organizational practices, processes, and structures. To fulfill this purpose, change agents work with knowledge that is either external or internal from a firm's perspective.

In this study, we contribute to the literature on organizational and technological innovation by investigating how hybrid change agents (i.e., change agents that draw equally on internal and external knowledge) moderate the influence of organizational innovation on technological innovation across the innovation cycle. In contrast to internal or external change agents, hybrid change agents are particularly suited for integrating and recombining internal and external formal knowledge and experience. Internal knowledge may, for example, be tacit or manifest in the form of handbooks, descriptions of processes, and routines. External knowledge tends to be less firm-specific and, in turn, more abstract, often publicly available. Thus, whereas the origins of knowledge and experience of internal and external change agents primarily stem from internal and external sources, respectively, hybrid change agents draw equally on internal and external sources.

Our study differs from previous research in three ways. First, we argue that organizational innovations differ in kind and that these differences have important implications for not only the antecedents but also the consequences of how organizational innovation may facilitate technological innovations. Consequently, we extend theories on organizational design (Whittington et al., 1999) and distinguish innovations in a firm's organization of business processes, work, and external relations. Second, we explore complementary effects across the entire technological innovation circle, from the knowledge creation phase through the knowledge codification phase to the knowledge commercialization phase. Third, by drawing attention to the particular role of hybrid change agents and revealing how they moderate the influence of organizational innovation on technological innovation, we show that hybrid change agents are particularly important for integrating external and internal knowledge and for adjusting general knowledge to firm-specific activities.

To investigate how hybrid change agents moderate the influence of organizational innovation on technological innovation over the innovation cycle, we draw on a sample of 1,240 firms in Switzerland. Switzerland provides a unique setting for our study. Switzerland is one of the most innovative countries and through its dual-track Vocational Education and Training (VET) system, educates a large population of apprentices (European Commission, 2016; Ryan, 2012) who can act as hybrid change agents. Apprentices learn not only theoretical knowledge through school-based education in the classroom but also practical knowledge through on-the-job training in firms. This education puts them in a unique position to integrate external knowledge with internal knowledge and to translate and adapt general knowledge to firm-specific activities.

2. Complementarities between technological and organizational innovation: theoretical considerations

2.1. Technological innovation

Research on technological innovation is centrally concerned with explaining the development of new products or processes and their diffusion in different markets. Most scholars agree that technological innovation matters because it is the driving force between market economies and contributes to the competitive advantages of firms. Researchers define technological innovation as either an outcome or a process (Kimberly and Evanisko, 1981). Those adopting an outcome perspective define technological innovation as the development of new products and processes or the improvement of existing products and processes (Damanpour and Aravind, 2012; Henderson and Clark, 1990; Tether and Tajar, 2008).

By contrast, researchers adopting a process perspective focus on understanding the individual steps and sequences of firms in developing an idea into a marketable product. These researchers emphasize that for firms to successfully innovate, they need to generate, codify, and utilize their intellectual capital. This procedural perspective is most explicit in research, emphasizing the innovation "process", that is, "the sequences of events that unfold as ideas emerge, are developed and are implemented" (Garud et al., 2013, p. 776).

Models of the innovation process commonly include three different stages (Garud et al., 2013; Kogut and Zander, 1992). The knowledge generation stage comprises activities targeted at generating the necessary knowledge for developing inventions, such as innovative products and processes. The knowledge codification stage serves to transform tacit and explicit knowledge into intellectual property (e.g., manuals, standard operating procedures, patents). Lastly, the knowledge utilization stage entails all activities that are targeted at bringing innovative products to the market (e.g., marketing, sales, licensing). Alternative models of the innovation process with more or less fine-grained stages exist. Nonetheless, common to all models is their comprehensive focus on those activities through which firms generate, codify, and utilize or commercialize their intellectual capital into innovative products and processes.

To better understand why some firms are better at innovating than others, researchers have focused on analyzing the factors that influence the innovation process. These factors belong to three categories: environmental factors, factors related to a firm's characteristics, and factors related to a firm's organization. For example, most innovation research considers environmental factors, such as the intensity of competition, exposure to global markets, and industry characteristics, to be important for explaining differences in firms' innovation activities and success (Damanpour, 1996; Evangelista and Vezzani, 2012; Rumelt, 1991). Similarly, researchers largely agree that firm characteristics, such as a firm's resource endowments (e.g., slack resources, R&D investments) or HR capital (e.g., workforce specialization and diversity), are important for explaining firms' different success in technological innovation. Finally, researchers have examined strategic and organizational design-related factors, such as a firm's structure or ambidexterity or open innovation strategy, as conducive to technological innovation.

2.2. Organizational innovation

Research on organizational innovation is increasingly paying attention to how firms develop and introduce new elements into their organizational design and what consequences such innovative elements have on a number of firm-relevant outcomes. Organizational innovation refers to the development and introduction of new organizational structures, processes, or practices (Birkinshaw et al., 2008; Pettigrew and Fenton, 2000). Typical examples of organizational innovation include, on the industry level, the M-Form and moving assembly line and, on the firm level, new methods of internal organization that affect the structuring of tasks, distribution of authority, or hierarchical layers of a firm (Damanpour and Evan, 1984; Hamel, 2007; Volberda et al., 2014). Thus far, most research on organizational innovation has focused on understanding the performance effects of organizational innovation, providing strong evidence for the important contribution of organizational innovation to the competitiveness of firms (e.g., Camisón and Villar-López, 2014; Mol and Birkinshaw, 2009; Sapprasert and Clausen, 2012).

More recently, researchers have examined the extent to which organizational innovations facilitate firms' development of new or improvement of existing products and processes. Recent evidence supports the view that "effective organizations introduce streams of different types of innovation over time", Damanpour and Aravind (2012: 24). Although technological and organizational innovation are distinct concepts that come about in different ways, several scholars have already argued for complementarities between these two innovation types (Damanpour and Aravind, 2012; Sanidas, 2005). For example, Nelson (1996, p. 118) argues that "new ways of organization are required to guide and support technological advances to enable firms to profit from them." Similarly, Lam (2005), stating that "technological innovation triggers organizational change because it shifts the competitive environment", speculates that organizational innovation may be a necessary precursor of technological innovation. Scholars have thus already suggested some ways in which technological and organizational innovation may complement one another.

In addition, a number of recent empirical studies has provided strong evidence for important complementarities between technological and organizational innovation (e.g., Battisti and Stoneman, 2010; Polder et al., 2010). For example, Camisón and Villar-López (2014) find that organizational innovation leads to the generation of more technological process innovation, but has no direct effect on technological product innovation. Likewise, Sapprasert and Clausen (2012) corroborate the substantial complementary benefits that firms enjoy by combining technological and organizational innovation. For example, these authors show that the introduction of new production techniques leads to new ways of organizing work and, consequently, to organizational innovation. Similarly, new ways of organizing work might recombine knowledge sources and thus generate new knowledge, leading to technological innovation. Thus, researchers have emphasized the intricate linkages between technological and organizational innovation, whereas recent evidence suggests that how organizational innovation influences technological change may be more nuanced than previously assumed.

2.3. Change agents in translating organizational innovation into technological innovation

When and how does organizational innovation, particularly that, which enhances technological innovation, come about? Most innovation research has focused on change agents to explain when and how organizational innovation occurs (Mol & Birkinshaw, 2009; Vaccaro et al., 2012). Change agents are key individuals who proactively create, experiment with, validate, and influence the development and implementation of new organizational practices, processes, and structures (Birkinshaw, Hamel, & Mol, 2008). Their activities constitute a major impetus for innovative organizational change within firms. Thus far, innovation research has almost exclusively distinguished between internal and external change agents at the managerial level or upper echelons, key individuals either inside (e.g., employees, managers, board members) or outside (e.g., consultants, analysts, academics) the organization (Birkinshaw et al., 2008; Nicolai, Schulz, & Thomas, 2010).

In this literature, most researchers have paid attention to internal change agents (e.g., Elenkov, Judge, & Wright, 2005; Huffman & Hegarty, 1993; Kimberly & Evanisko, 1981). For example, Vaccaro et al. (2012, p. 37) focus on CEOs and other top executives as key internal change agents "as they will be key in driving, championing, and pursuing changes in practices, processes, and structures." Relatedly, Heyden, Sidhu, and Volberda (2017) explore the differences between top and middle managers on influencing organizational innovation and provide new insights into the role of top and middle management characteristics in organizational innovation. Internal change agents primarily draw on, and contribute to, internal knowledge sources, such as handbooks, patents, and descriptions of processes and routines. Such internal knowledge tends to be firm specific and thus unique to each firm's operations. Thus, internal change agents are key individuals for understanding a firm's idiosyncrasies. These change agents benefit from their familiarity with the company and their strong internal network to mobilize support for initiatives. However, internal change agents may also suffer from organizational blindness, a form of myopia that prevents them from holistically assessing the value of firm activities (Knudsen, 2011; Levinthal & March, 1993). Research on internal change agencies provide important insights into how different leadership styles of top executives influence a firm's success in pursuing organizational innovation.

Less research has explored the potential influence of external change agents. Birkinshaw et al. (2008, p. 840), in their seminal work on how organizational innovation comes about, identify consultants and academics as key external change agents involved in organizational innovation. By contrast, Nicolai et al. (2010) explore how analysts help diffuse management practices within the financial industry. External change agents draw more heavily on abstract and less firm-specific knowledge sources. These change agents use skills and experience gathered in multiple organizations, articulating and codifying knowledge that facilitates its transferability and replicability (Winter & Szulanski, 2001). Firms need to translate and adjust external knowledge to the idiosyncratic elements of a firm's activities to benefit from this knowledge. Thus, external change agents may draw on a wider array of solutions that have worked in a number of other contexts. However, external change agents also suffer more than internal agents from "causal ambiguity" in that they find it more difficult than internal agents to identify and understand the causal relationship between the input and output side of a firm's activities (Reed & DeFillippi, 1990). Research on external change agents suggests that their strength primarily lies in their ability to combine the experience of multiple firms and theorize from their insights to develop knowledge that is more abstract.

In summary, to date, research has provided important insights into how internal or external change agents facilitate the design and implementation of disruptive organizational innovation. Most studies focus on change agents at higher managerial levels, providing a better understanding of how new organizational practices, processes, and structures trickle down from the upper echelons to the lower levels of an organization. The focus on individuals at upper echelons is understandable because these disruptive innovations are easier for executives to communicate and constitute a prime market for consultancies (Hammer, 2004).

However, this selective focus has led research on organizational innovation to neglect the role of hybrid change agents in implementing organizational innovation that help firms to more successfully develop new and improve existing products and processes. We focus on this 'third' type of change agent. Following Birkinshaw et al. (2008, p. 840), who point towards the underexplored question of how change agents "are able to take on hybrid internal/ external roles", we argue that hybrid change agents command of skills and experiences is unique and different to those of internal and external change agents.

In contrast to both internal and external change agents, hybrid change agents draw equally on internal and external sources of knowledge. Hybrid change agents comprise firm-specific experience within the company but are also exposed to, and may draw on, formal and abstract external knowledge. Hybrid change agents combine experience within the company with formal knowledge from outside the company. Drawing on both external and internal knowledge sources also fosters hybrid change agents' skills in integrating external and internal knowledge. Integration may go both ways: either abstracting from firm-specific experiences to general principles or drawing on general principles to better understand, make sense of, and thereby, improve firm-specific practices. Thus, hybrid change agents differ from internal and external change agents in that they suffer less from organizational blindness, as internal agents do, and causal ambiguity, as external agents do. The ability of hybrid change agents to integrate external with internal knowledge facilitates the translation and adaptation of formal knowledge to the idiosyncratic business activities of a firm.

We argue that the ability of hybrid change agents to traverse this divide and enact dual change agents roles (Birkinshaw et al., 2008) makes them uniquely suited to provide important directions to innovate and smoothen the implementation of new processes or structures. Hybrid change agents are not the only source for developing and implementing new organizational practices, processes, and structures. As others have shown, the impacts of internal and external agents at higher or middle management levels differ (Heyden et al., 2017). These findings suggest that although hybrid change agents, particularly those at lower echelons, should be less influential for initiating disruptive new elements in a firm's organizational design, they may be important for initiating improvements in existing practices, processes, and structures. Moreover, the unique skills of hybrid change agents at integrating external and internal knowledge sources should make them particularly suited for improving the complementarities among technological and organizational innovation. To develop a better understanding of the role of hybrid change agents in fostering the complementarities between technological and organizational innovation, in this study, we ask how hybrid change agents influence the impact of organizational innovation on technological innovation across the innovation process.

2.4. Apprentices as hybrid change agents

We examine a particular type of change agent, namely, apprentices enrolled in the Swiss secondary vocational education and training system (VET). We suggest that apprentices are best conceptualized as “hybrid” change agents because—due to the very nature of dual vocational education and training—apprentices acquire knowledge simultaneously from outside and inside the firm and frequently move back and forth between the outside and inside of a firm.

VET systems, such as those in Switzerland, Germany and Austria, provide high-quality training at the secondary level. In Switzerland, each VET program is structured along a nationally standardized curriculum that regulates training in schools and on-the-job training (Wolter and Ryan, 2011). These standardized curricula are subject to a constant monitoring and updating system, a task performed by national curriculum councils composed of educational experts and representatives from employer associations, employee associations, and the government.

VET differs from a purely academic education not only in its content but also in its structure, for example, by using different training methodologies and by requiring at least two training entities, the schools and companies. VET integrates theoretical knowledge through in-class education in vocational schools and intercompany training centers with practical knowledge through on-the-job training in firms (Wolter and Ryan, 2011). Apprentices learn not only the theoretical but also the practical skills relevant for their occupation. The combination of theoretical (scientific) and practical skills supports the generation of innovation (e.g. Herrmann and Peine, 2011). Thus apprentices can be seen as hybrid change agents, because they constantly combine theoretical knowledge from vocational schools, which is an external knowledge source from a firms' perspective with practical knowledge from workplace training, which is an internal knowledge source.

The knowledge that apprentices bring to firms differs significantly from that of managers and employees or consultants and external coaches. The continuous review of training curricula has the effect that the theoretical skills that apprentices learn in vocational schools and intercompany training centers are continuously up to date. By frequently updating national training curricula, VET diffuses new knowledge among firms. Prominent examples for the diffusion of knowledge via VET are the introduction of knowledge on computerized numerical control (CNC) machines in curricula of machining mechanics and the introduction of knowledge on high-voltage engines in curricula of car mechanics (Ryan, 2012).

Firm-level studies have also shown that the knowledge of apprentices—transmitted through VET—differs significantly from that of other employees, such as those with an academic education (e.g., engineers, scientists, lawyers) and those without any formal education (Rupietta and Backes-Gellner, 2019b). Secondary-educated workers with VET degrees have knowledge that workers with tertiary academic education do not have. Apprentices thus provide a unique source of knowledge, knowledge that is heterogeneous and complementary to that of other employees and helps firms to develop process and product innovation.

In summary, VET provides firms with an opportunity to access a particular source of knowledge: external knowledge through content taught in vocational schools and intercompany training centers that apprentices combine with internal knowledge through on-the-job training at the workplace. Those firms that participate in the national VET system may benefit from a continuous and systematic inflow of unique knowledge. By simultaneously adopting internal and external roles, apprentices may thus serve as hybrid change agents in facilitating the influence of organizational innovation on a firm's propensity to develop new or improve existing products and processes. Switzerland, which has an educational system that offers firms a wide range of academic and vocational knowledge, is therefore an ideal setting for exploring how apprentices—as hybrid change agents—moderate the effect of organizational innovation on technological innovation.

3. Empirical study

3.1. Data

For our empirical analysis, we use data from the 2013 Innovation Survey collected by the Swiss Economic Institute (KOF).[2] The KOF Innovation Survey is aligned with the EU Community Innovation Survey (CIS) and has become a valuable resource for innovation research in Switzerland (e.g., Beck et al., 2016; Hollenstein, 2003). In addition to the established measures for technological innovation and firms' participation in VET, the KOF innovation survey in 2013 included an additional topical issue section that focuses on aspects of organizational innovation. These questions now ask firms whether they have introduced new methods for the organization of business processes, such as quality management, lean production, or knowledge management. The combination of established and unique indicators for technological innovation, organizational innovation, and firms' participation in VET makes the KOF Innovation Survey 2013 a unique resource to address our research question.

3.2. Variables

3.2.1. Outcome variables: Technological innovation across the innovation process

To measure technological change across the innovation process, we select five indicators that reflect three phases in the innovation process: knowledge generation, knowledge codification, and knowledge utilization. Two measures cover the knowledge generation phase. First, following Camisón and Villar-López (2014), *product innovation* is a binary measure that

[2] The 2013 wave of the Swiss Innovation Survey covers 2034 firms and is a representative sample of the Swiss firm population. The original sample has missing values in several of the variables that we use in our empirical model. The final sample we use for our empirical analysis covers 1240 firms. We compared the original sample with the restricted sample, and the results do not indicate major differences. Nevertheless, we find that the full sample contains more firms that have applied for a patent. We provide a summary table of the sample comparison in table A.1 in the Appendix.

indicates whether a firm has developed a new technological product. Second, *process innovation* is a binary measure that indicates whether a firm has developed a new technological process. Third, to cover the knowledge codification stages, we use *patent applications*, a well-established measure in the innovation literature that indicates whether a firm has codified the knowledge it uses for generating an innovation (e.g., Kaplan and Vakili, 2015; Roper and Hewitt-Dundas, 2015). Our patent measure is binary and indicates whether a firm applied for a patent in the past three years. Two final measures cover the knowledge utilization stage. Fourth, as a measure for incremental innovation, we use the percentage of *sales of improved products*. Fifth, as a measure for radical innovation, we use the percentage of *sales of new products*. In summary, our five measures are established measures for each of the three stages of the technological innovation process and allow us to explore how hybrid change agents moderate the influence of organizational innovation on technological innovation.

3.2.2. Explanatory variables

Our model includes three types of explanatory variables. The first type contains a set of three different organizational innovations for which use the following items as measures: (i) for *innovation in the firms' business processes*, a binary variable that indicates whether a firm introduces quality control, lean management, supply chain management, or knowledge management; (ii) for *innovation in the firm's organization of work*, a binary variable that indicates the introduction of teamwork or job rotation, or shifts in the distribution of competences; and (iii) for *innovation in the firm's organization of external relations*, a binary indicator that reflects the formation of new alliances, new cooperation agreements, or new customer relations. These measures are in line with other studies on organizational innovation (e.g., Armbruster et al., 2008; Camisón and Villar-López, 2014; Evangelista and Vezzani, 2010). However, our measures allows us to go beyond previous research by exploring how conceptually distinct elements of a firm's organizational design affect its propensity for technological change across the innovation cycle.

The second type of explanatory variable measures a firms' participation in VET. The KOF Innovation Survey contains information on the employment of apprentices. To measure firms' participation in VET, we define a binary variable that indicates whether a firm trains apprentices and thus participates in VET. Our variable takes a value of 1 if the firm is a *training firm* and 0 otherwise.

The third set of explanatory variables includes interaction terms of our measures for organizational innovation (i.e., innovation in business processes, innovation in the organization of work, and innovation in firms' external relations) and our measure for firms' participation in VET. These interaction terms provide insights into the moderating role of apprentices in the association between organizational innovation and technological change.

3.2.3. Control variables

The KOF Innovation Survey contains a rich set of items that allow us to control for alternative explanations for technological innovation. Specifically, we include nine sets of control variables: (i) firm size as the total number of employees; (ii) the educational background of a firm's workforce, measured as the percentage of employees with the same education level (we distinguish between employees with a university degree, PET degree, VET degree and other degree); (iii) competition intensity using five categories of the number of competitors (1 = have up to 5 competitors, 2 = 5-10, 3 = 11-15, 4 = 16-50, 5 = more than 50); (iv) price and non-price competition on a 5-point Likert scale, ranging from 1 (very low competition) to 5 (very high competition); (v) export orientation (a binary variable, 1 if a firm exports goods or services, 0 otherwise); (vi) past and expected demand with an item on a 5-point Likert scale ranging from 1 (strong decline in demand on the main product market) to 5 (strong increase in demand); (vii) technological potential of the industry measured on a 5-point Likert scale ranging from 1 (very low) to 5 (very high); (viii) sectoral control variables[3]; and (ix) regional control variables[4].

3.3. Methods

To analyze how hybrid change agents moderate the association between organizational innovation and technological innovation, we specify an estimation equation with interaction terms, a standard way to estimate moderations. Our estimation strategy distinguishes different types of organizational innovation and measures both their direct associations as well as their (through VET) moderations across the entire technological innovation process. We specify the following estimation equation:

$$inno_j = \beta_0 + \sum_{k=1}^{3} \beta_k oi_{kj} + \beta_4 tr_j + \sum_{k=1}^{3} \gamma_k oi_{kj} * tr_j + \sum_{l=1}^{L} \varphi_l x_{lj} + v_j \qquad (1)$$

Equation (1) is the basic estimation equation that we use in our empirical analysis. The outcome variable in equation (1) is $inno_j$, a measure for a technological innovation that firm j generates. The explanatory variables are measures for organizational innovation oi_j. Moreover, according to our theoretical model, we distinguish three measures for organizational innovation: organizational innovation in business processes, the organization of work, and external relations. All three measures are binary variables that indicate whether a firm has implemented an organizational innovation. The variable tr_j is a binary variable that indicates whether firms train apprentices. We include the main term and the interaction term of apprentices with the three measures for organizational innovation. The sum $\sum_{l=1}^{L} x_{lj}$ indicates L usual control variables. such as firm characteristics, environmental characteristics, and sectoral and regional controls.

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3 The KOF Innovation Survey uses the official sectoral classification of the Swiss Federal Statistical Office to distinguish the following sectors: (i) manufacturing, including traditional and high-tech manufacturing, (ii) construction, and (iii) services, including traditional and modern services.

4 The KOF Innovation Survey uses the regional classification of the Swiss Federal Statistical Office to distinguish the following seven Swiss regions: (i) Lake Geneva Region, (ii) Espace Mittelland, (iii) Northwestern Switzerland, (iv) Zurich, (v) Eastern Switzerland, (vi) Central Switzerland and (vii) Ticino.

3.4. Analysis

After eliminating observations with missing values, our sample contains 1,240 observations. Table 1 provides detailed descriptive statistics of our sample. Firms have on average 208 employees and range between 3 and 28,666 employees.[5] Thus, our sample covers the entire spectrum of firm sizes ranging from small to very large. Most of the firms are from the manufacturing (49.7%) and the service sectors (41.1%). The remaining firms operate in the construction sector (9.2%). Our sample represents firms from all regions of Switzerland.

Insert Table 1 about here

Table 1 also shows descriptive statistics of the outcome and main explanatory variables of our estimation model. In our sample, 43.0% of the firms generate technological product innovation, and 31.6% generate technological process innovation (21.3% generate both, technological product and process innovation). Only a few firms (12.2%) report patent applications, providing evidence that not all product and process innovations are sufficiently new or original to suffice the requirements for patent applications. Moreover, as the descriptive statistics on the sales of new and improved products indicate, firms successfully commercialize their innovation: 6.7% of the sales result from improved products (incremental innovation) and 5.8% result from new products (i.e., either new to the firm or new to the main market). Overall, these number show that firms in our sample successfully generate, codify, and utilize knowledge.

[5] The KOF Innovation survey only includes firms that have more than 5 employees (incl. apprentices). The firm size measure in this study does not include apprentices.

The descriptive statistics for the explanatory variables show that most firms in our sample (71.0%) train apprentices.[6] This finding is not surprising as VET is the most widespread form of education after compulsory schooling. In addition, our descriptive statistics show that the firms in our sample generate different forms of organizational innovation. Innovation in business processes (34.3%) and innovation in the organization of work (33.5%) are more widespread than innovation in external relations (22.0%). Our findings on the prevalence of organizational innovations are thus similar to those of studies conducted in other European countries (e.g., Evangelista and Vezzani, 2010; Sapprasert and Clausen, 2012) and indicate that approximately one in three firms make several adaptions to their organizational design.

Insert Table 2 about here

Table 2 shows the correlations between the outcome variables and the main explanatory variables. We find strong and statistically significant positive correlations between our five measures for technological innovation, providing evidence that if firms seek to innovate, they need to engage in knowledge activities across the entire innovation process. We also find strong and statistically significant positive correlations between organizational innovation and technological innovation. These correlations are in line with previous findings in the literature on the complementarity of organizational and technological innovation (e.g., Evangelista and Vezzani, 2010; Sapprasert and Clausen, 2012) and suggest that technological innovation often

[6] The training participation of firms in Switzerland is approximately 20%. In our sample 71% of the firms train apprentices. Training participation increases with firm size (Müller and Schweri, 2012). The high percentage of training firms results from the sampling of the KOF Innovation Survey and data cleaning. The KOF Innovation Survey only includes firms with more than 5 employees. The sampling procedure includes disproportionally less smaller firms than larger firms. All as large firms (i.e., with 250 employees and more) were included in the initial sample. In addition smaller firms are more likely to return incomplete questionnaires. The higher training participation in our sample results thus from a sample that mainly includes larger firms.

occurs together with organizational innovation. Finally, we find positive and statistically significant correlations between a firm's participation in training and both technological and organizational innovation. These findings provide the first evidence that participation in VET, and thus the training of apprentices, may play an important role in firms' innovation processes.

4. Results

According to our theoretical model, we expect hybrid change agents to moderate the association between organizational innovation and technological change. We show the results of our empirical analysis of in Table 3. The five specifications in this table show how hybrid change agents moderate the association between organizational innovation and technological change over the entire technological innovation process. We include five outcomes (product innovation, process innovation, patent applications, sales of improved products, and sales of new products) that correspond to the three stages of the technological innovation process: knowledge generation, knowledge codification, and knowledge utilization.

Insert Table 3 about here

Equation (1) contains four main terms, one for the training of apprentices, and three for organizational innovation. We also include three interaction terms between training and organizational innovation. The association between patent applications and training apprentices is statistically significant. As Table 3 also shows, we find a positive association of organizational innovation across the technological innovation process. We find that innovation in business processes is positively associated with technological process innovation. The coefficient indicates that firms with innovations in business processes have a 30.6 percentage points higher probability of technological process innovations than firms without innovations in business processes. Innovation in the organization of work is positively associated with the sales of improved products. Firm with innovations in the organization of work have a 3.78 points higher percentage of sales of improved products. For innovation in a firm's external relations, we find no statistically significant association with any of the five outcomes.

Moreover, innovation in business processes affects the knowledge generation stage and goes along with innovation in technological processes. Innovation in the organization of work affects the knowledge utilization stage and improves the production and commercialization of improved products. We do not find a positive relationship between any type of organizational innovation and radical types of technological innovation. In summary, organizational innovation has no uniform association with the technological innovation process. Instead, as our results show, organizational innovations primarily foster the generation of incremental technological innovation but not the generation of radical innovations.

The results in Table 3 support our theoretical expectations. Training apprentices in combination with innovation in the organization of work positively influences technological process innovation. The probability of having technological process innovations increases by 19.7 percentage points. Training apprentices in combination with innovation in business processes positively affects the probability of patent applications and the sale of improved products. The probability for patent applications increases by 14.4 percentage points and the percentage of sales of improved products by 5.4 points. As the insignificant coefficients for sales of new products indicate, a moderation occurs for incremental types of technological innovation but not for radical types of technological innovation. In summary, we find that apprentices moderate the association between organizational innovation and technological innovation positively over all phases of the technological innovation process. The sizes of the coefficients show a strong association between organizational innovations and its interaction with training participation with technological process innovation.

Our results are in line with the results of other studies investigating the influence of organizational innovation on technological innovation (e.g. Camisón and Villar-López (2014), Sapprasert and Clausen, 2012). The study of Camisón and Villar-López (2014) is closest to our. It analyzes the effect of organizational innovation on technological process innovation and on product innovation with Spanish firm data. It finds statistically significant correlations between organizational innovation and technological process innovation, and between organizational innovation and product innovation. In their multivariate analysis with a structural equation model, they only find a statistically significant positive coefficient for the effect of organizational innovation on technological process innovation. Our result for the main effects of organizational innovation is lower due to the inclusion of the interaction with the training participation variable. The interaction of innovations in business processes and training participation has a positive coefficient and is statistically significant and thereby indicates an indirect effect of organizational innovation on technological innovation. In summary it is important to note that the results of our study are consistent with findings of similar studies with respect to the influence of organizational innovations on technological innovations.

5. Discussion and conclusion

This article analyzed the role of apprentices in the innovation process of firms. It focused explicitly on analyzing the role of apprentices in the complementarity between technological and organizational innovation. Thus far, research on organizational and technological innovation has rarely examined the multi-facetted influence of different organizational innovations across the technological innovation process. Additionally, although researchers have explored the role of change agents at upper echelons (e.g., CEOs, board members, academics, consultants), the role of hybrid change agents at lower echelons remains neglected. In this paper, we investigate how apprentices in the Swiss VET system, as hybrid change agents at lower echelons, influence the association between organizational innovation and the technological innovation process. Our findings provide important contributions to the literature on organizational innovation and to the literature on VET.

5.1. Implications for research on complementarities between technological and organizational innovation

Thus far, research concerned with understanding the role of change agents in organizational innovation has primarily focused on key individuals in the upper echelons, either external (e.g., consultants, academics) or internal (e.g., CEOs, board members). Findings suggest that key individuals at the upper echelon are crucial for introducing more radical organizational innovation, such as fundamental innovation in firms' business models or external relations by merging or acquiring other firms (Birkinshaw et al., 2008; Mol and Birkinshaw, 2009). Key individuals at mid-level managerial levels appear to be more effective for developing and implementing less radical organizational innovation (Heyden et al., 2015).

By exploring the role of hybrid change agents at lower echelons, our study contributes to a better understanding of the role of change agents in organizational innovation in two ways. First, we reveal that hybrid change agents affect the technological innovation process through multiple channels. Training of apprentices is directly associated with technological innovation by supporting codification efforts. Moreover, training of apprentices has an indirect influence by moderating the positive associations of organizational innovation with all stages of the technological innovation process. The results indicate that firms may benefit from including hybrid change agents in the technological innovation process.

Second, our results indicate that hybrid change agents are important for translating knowledge and facilitating the adaptation of knowledge to the idiosyncrasies of firms' activities that lie in the core of the firm. Training apprentices helps firms adopt innovative workplace practices that improve firms' process innovation capabilities and implement innovative business processes that increase firms' sales of improved products. Our findings suggest that the positive association of hybrid change agents with technological innovation is more indirect than direct. Moreover, apprentices appear to be particularly skilled at innovating organizational elements that are central to the firm (e.g., daily workplace practices, business processes) rather than those on the boundaries of the firm. Thus, hybrid change agents at lower echelons exert particularly positive conjoint effects in the core of a firm's activities.

We also contribute to the literature on the interplay between organizational and technological innovation. Thus far, most research has treated organizational innovation as a single and broadly defined concept (e.g., Camisón and Villar-López, 2014; Sapprasert and Clausen, 2012). For example, Battisti and Stoneman (2010) treat all types of organizational innovation equally, such as the introduction of cross-functional teams or outsourcing of business functions. Likewise, Vaccaro et al. (2012) consider changes in organizational rules and functions, newly implemented management systems, and continuous changes to certain elements of the organizational structure as indicators of the same concept.

By contrast, we argue that distinguishing different types of organizational innovation is important for explaining how organizational innovation affects firm-relevant outcomes, such as performance or innovation. Extending theories of organizational design (Whittington et al., 1999) to research on organizational innovation, we propose distinguishing innovation into theoretically distinct organizational elements: the business processes, organization of work, and firm's external relations. Our results indicate that organizational innovations influence the technological innovation process at different stages. Disentangling these different effects is important because they influence single phases of the technological innovation process in substantively different ways. For example, we find innovation in the firm's business processes to be linked directly to technological process innovation, corroborating previous suggestions that 'hard' processes only function when supported by 'soft' processes (Whittington et al., 1999). Moreover, we find that innovation in the firm's organization of work primarily affects incremental innovation (i.e., an increase in sales of improved products). Together, our findings suggest that firms primarily unleash major efficiency gains by restricting the way their employees perform activities.

In addition, we provide in-depth insights into how new organizational practices, processes, and structures may influence different phases in the technological innovation process. Previous research has focused almost exclusively on the knowledge generation phase, investigating either the influence of organizational innovation on the innovation capabilities of firms (Camisón and Villar-López, 2014) or the invention of new technological products or processes (Evangelista and Vezzani, 2010). We extend previous models by considering how organizational innovation influences not only the knowledge generation phase but also two downstream phases in the technological innovation process: knowledge codification and knowledge commercialization. In contrast to most other studies, we find no association of organizational innovation with product invention. One possible explanation for our divergent findings may lie in the fact that, contrary to previous approaches, we do not aggregate items into a coarse indicator for organizational innovation but separately consider three elements in the organizational design of a firm. Thus, without a more fine-grained approach to measuring organizational innovation, previous research may have overestimated the potential synergies that firms may enjoy by implementing multiple streams of innovation simultaneously.

We also find no association of organizational innovation with the sales of new products (radical technological innovation). Overall, these findings suggest that organizational innovation is of little help when firms have to develop or commercialize new products. For these innovation activities, technological know-how and skills remain more important. Organizational innovation, however, appears beneficial for facilitating the invention of new technological processes or for increasing the sales of improved products.

Overall, we contribute to the literature on organizational innovation by providing additional evidence for the positive influence of organizational on technological innovation (Battisti and Stoneman, 2010; Evangelista and Vezzani, 2010). Drawing on theories of organizational design to distinguish organizational innovation at different levels of the organization (Whittington et al., 1999), we reveal micro-mechanisms of three types of organizational innovation that generate an effect on technological innovation. Moreover, highlighting the role of agency as an important explanatory element, we show how hybrid change agents influence the link between organizational and technological innovation.

5.2. Contribution to the literature on VET systems

First, we provide a new explanation for the beneficial effect of VET on a firm's innovation process. Prior international (Anglo-Saxon) studies conceptualize vocational education as a form of education that has a focus on firm-specific skills, which are overly narrow and strongly connected to a certain technology that a firm uses (e.g., Krueger and Kumar, 2004). According to this literature these skills do not contribute to innovation in firms because firm-specific skills become obsolete when technology changes. However, dual VET, one special form of vocational education, has a strong focus on general skills and thus does not fit into this conceptualization. Rupietta and Backes-Gellner (2019a) analyze knowledge diffusion in a dual VET system and argue that the institutional foundations of the dual VET systems, such as the ones of Switzerland, Germany, and Austria, not only ensure the constant inflow of new and innovation-relevant knowledge but also help to diffuse this knowledge among all firms participating in the VET system by training apprentices. Our findings, by indicating how knowledge from the VET system enters firms and is associated with their innovation process, help to uncover an additional channel for the positive effect of VET on a firm's innovation process. We show that apprentices clearly play a central role in this mechanism.

Second, we provide evidence for significant benefits of VET on the technological innovation processes of Swiss firms. In countries with a similar VET system, such as Germany, and Austria, apprentices may represent hybrid change agents that help internalizing and processing external knowledge. These countries tend to be particularly good at capturing and exploiting the long-term rents from their innovation (European Commission, 2016). That Switzerland is one of the most innovative countries globally provides strong indication of the importance of a well-functioning VET system for the innovativeness and internal functioning of a country's firm population (see also Meuer et al., 2015).

Third, we argue that our findings may provide an additional explanation for why countries with similar VET systems innovate so successfully and sustainably. We conceptualize apprentices as hybrid change agents to explain how firms may internalize knowledge from the VET system for their innovation process. Hybrid change agents are capable of processing both internal and external knowledge and thus of internalizing external knowledge. Apprentices are hybrid change agents because they operate during their training with internal knowledge, through on-the-job training, and external knowledge, through school-based learning and intercompany training center learning. During their training, apprentices learn how to connect both internal and external knowledge. Thus, apprentices have an important role in the implementation of change processes in a firm because they can effectively connect external knowledge in a change process and thereby improve the outcome of such a process.

This ability to connect internal and external knowledge appears particularly useful when firms implement organizational innovation, such as new business processes or new ways of organizing work. Apprentices improve the implementation of organizational innovation at lower echelons and thereby also leverage the effect of organizational innovation on the technological innovation process. The conceptualization of apprentices as hybrid change agents who help firms to internalize external knowledge and thereby support organizational innovation thus offers a novel explanation for the positive effect of VET on innovation at the firm level.

5.3. Concluding remarks

Our study is limited in five ways concerning its methodological, conceptual, and location-specific aspects. We discuss these limitations in detail and offer opportunities for future research to develop further insights into the role of hybrid change agents in organizational innovation and in the influence of these organizational innovations on firms' technological innovation process.

First, we have highlighted the role of hybrid change agents at lower levels in developing and implementing new organizational practices, processes, and structures that impact a firm's technological innovation process. Specifically, we have shown that hybrid change agents at lower echelons are important for intensifying the impact of organizational innovations, such as organizing daily work or continuous business practices, on technological innovation.

However, in our study, we have not considered hybrid change agents at upper echelons and have not explored the relative effectiveness of change agents at different managerial levels. Hybrid change agents may also influence organizational innovation from the upper echelons. For example, venture capitalists adopt both an external role by investing in a portfolio of firms and an internal one by participating in managerial decisions. Relatedly, we have also not compared the relative influence of hybrid change agents against that of internal and external change agents. Future research may validate and extend our findings for example by exploring the role of hybrid change agents at the upper echelons or by directly comparing the influence of different change agents on organizational innovation.

Second, despite the importance of organizational innovation for explaining a firm's competitive advantages, research on organizational innovation remains severely restricted by the fact that questions and measures for organizational innovation remain under-developed (e.g., Armbruster et al., 2008; Wolfe, 1994). In our article, we follow prior research on organizational innovation and use the same, or at least similar, items to retain a high level of external validity across studies. However, our measures lack important conceptual elements to study such questions, such as covering explicitly the reasons and motivation of firms introducing new practices, processes, and structures. Our measures also do not consider the degree to which organizational elements are new merely to the firm or new to the market, industry, or region. Survey questions on technological innovation already cover these aspects of innovation, for example by asking if products are new to the firm or new to the firm's main market. Research on organizational innovation would benefit strongly from more precise survey items such as these.

Third, we have conceptualized apprentices in the Swiss VET system as hybrid change agents and have identified benefits of firms that operate in the Swiss VET system. However, internationally, VET systems appear in a wide variety and although the Swiss VET system is similar to the ones in, for example, Germany and Austria, it differs significantly to what is found under the name of apprenticeships in countries such as the UK, the USA, and Australia. In other countries, VET education is often purely firm specific or purely school based, thereby prohibiting the learning of general skills (and the transfer of employment opportunities between firms) or practical skills, respectively. Future research may explore, for example, the extent to which firms operating in countries with substantively different VET systems or foreign firms in VET countries are able to benefit from the additional impact of VET on their technological innovation processes.

Fourth, data limitations do not allow a more detailed investigation of different types of training strategies. The data set only allows us to construct a dummy variable for firms that offer VET or not, however we do not have further information on the particular design of the workplace training in training firms. The literature suggests that training strategies in firms may differ strongly and therefore distinguishes, for example, investment strategies from substitution strategies (see Mohrenweiser and Backes-Gellner, 2010). It seems plausible that firms that invest in the human capital of their apprentices and that involve them in complex productive tasks will prepare them to become hybrid change agents, because the apprentices have to connect different knowledge sources to find appropriate solutions. More data on how firms train and how apprentices access and use different knowledge sources (i.e., use textbooks, manuals, patents, and / or collaborate with different partners) would be helpful to understand how apprentices manage different knowledge sources. Future research should therefore try to investigate how training strategies prepare apprentices to effectively bridge between different knowledge sources.

Fifths, while the identification of a causal moderating effect of hybrid change agents on the effect of organizational innovation on technological innovation would be desirable, our empirical approach is not able to deliver this result. Thus our results can only be interpreted as associations between the key variables in our model. Nevertheless, we are able to provide a first indication that additional channels for the effect of VET on innovation may exist and describe that one channel may work through organizational innovation.

Our empirical analysis does also not preclude other indirect mechanisms through which a firm's participation in VET can lead to higher innovation outcomes. VET focusses on apprentices and prepares them to acquire professional competence in a selected occupation. Through the focus on the individual level (i.e., the apprentice as hybrid change agent) higher-level (organizational level) constructs that play an important role for innovation in firms may be influenced. VET may influence innovation in companies through at least two channels:

First, for an organization it is crucial to absorb relevant external knowledge to innovate. This absorptive capacity depends on relevant prior knowledge of individuals, the communication of the firm and the environment and the internal communication and coordination within a firm (Cohen and Levinthal, 1990). With respect to the prior knowledge of individuals, Cohen and Levinthal (1990) state "In a setting in which there is uncertainty about the knowledge domains from which potentially useful information may emerge, a diverse background provides a more robust basis for learning because it increases the prospect that incoming information will relate to what is already known. In addition to strengthening assimilative powers, knowledge diversity also facilitates the innovative process by enabling the individual to make novel associations and linkages." (Cohen and Levinthal, 1990, p. 131). By exposing apprentices to different knowledge sources and helping them to gain theoretical understanding and know-how at the same time, they diversify their knowledge background and will be prepared to make novel associations between previously unconnected knowledge sources. VET may thus influence a firm's absorptive capacity by preparing individuals to make linkages between different theoretical and practical knowledge sources and between internal and external knowledge sources. In addition apprentices may contribute to the implementation of organizational innovations that strengthen the organizational part of absorptive capacity.

Second, innovation may result from different learning modes. These learning modes differ by the type of knowledge they are predominantly using (Jensen et al, 2007). While the Science, Technology and Innovation (STI) mode builds on explicit knowledge such as in textbooks, manuals, and patents, the Doing, Using and Interacting (DUI) mode builds on tacit knowledge that individuals acquire through learning-by-doing or learning-by-observing. In VET these modes are connected with the STI mode being dominant in vocational schools and the DUI mode in workplace training (Rupietta and Backes-Gellner (2019a). Apprentices who combine these different knowledge types may facilitate innovation according to one of the modes or a combination of both, which is expected to have a superior innovation potential (Jensen et al., 2007). However, due to empirical limitations it is not possible to identify the exact causal mechanism but our results point to fruitful directions for future research on the influence of hybrid change agents on organizational level constructs.

In summary, we expand the view on hybrid change agents by shifting the focus from hybrid change agents at higher echelons to hybrid change agents at lower echelons. We show that these hybrid change agents positively moderate the relationship between organizational innovation and technological innovation over the entire technological innovation cycle. By focusing on apprentices as hybrid change agents, we highlight that training programs, such as VET, place apprentices simultaneously in internal and external roles. Such programs teach apprentices how to abstract from their experience and idiosyncratic knowledge to general principles and to internalize external and general knowledge to make it usable to firm-specific tasks. Thus, a training program can prepare future employees to take on hybrid roles at lower echelons. In this way, the training program accelerates the dissemination and combination of different types of knowledge in a firm and supports the generation of innovation.

Tables and Figures

Table 1
Descriptive statistics of firms (n=1,240) included in the analysis.

	Mean	Std. dev.	Min	Max
Outcomes				
Product innovation	0.430	0.495	0	1
Process innovation	0.316	0.465	0	1
Patent applications	0.122	0.327	0	1
Sales of improved products (in % of…)	6.670	14.249	0	100
Sales of new products (in % of…)	5.587	12.277	0	100
Explanatory variables				
Training Firm	0.710	0.454	0	1
Innovation in the firm's business processes	0.343	0.475	0	1
Innovation in the firm's organization of work	0.335	0.472	0	1
Innovation in the firm's external relations	0.220	0.415	0	1
Controls				
Firm size	208.407	956.200	3	28666
Workforce educational background (in %)				
Employees with university degree	7.963	13.965	0	100
Employees with PET degree	18.127	16.097	0	100
Employees. with VET degree	51.140	24.026	0	100
Employees. with other degree	23.158	23.521	0	100
Competition intensity (in %)				
Up to 5 competitors	0.288	0.453	0	1
6-10 competitors	0.301	0.459	0	1
11-15 competitors	0.105	0.306	0	1
16-50 competitors	0.143	0.350	0	1
More than 50 competitors	0.151	0.358	0	1
Price and non-price competition				
Price competition	3.969	1.010	1	5
Non-price competition	3.018	0.939	1	5
Export				
Export orientation	0.518	0.500	0	1
Demand				
Past demand	2.929	1.067	1	5
Expected demand	3.031	0.836	1	5
Technological potential				
Technological potential of industry	2.677	1.143	1	5
Sectors (in %)				
Manufacturing	0.497	0.500	0	1
Construction	0.092	0.289	0	1
Services	0.411	0.492	0	1

Regions (in %)				
Lake Geneva Region	0.110	0.314	0	1
Espace Mittelland	0.215	0.411	0	1
Northwestern Switzerland	0.131	0.337	0	1
Zurich	0.195	0.396	0	1
Eastern Switzerland	0.193	0.395	0	1
Central Switzerland	0.097	0.296	0	1
Ticino	0.060	0.237	0	1

Table 2
Correlation table of outcome and main explanatory variables

		1	2	3	4	5	6	7	8
1	Product innovation	1							
2	Process innovation	0.333***	1						
3	Patents	0.408***	0.245***	1					
4	Sales of improved products	0.538***	0.239***	0.296***	1				
5	Sales of new products	0.524***	0.188***	0.244***	0.358***	1			
6	Training Firm (TF)	0.072**	0.076***	0.102***	0.029	-0.018	1		
7	Innovation in the firm's business processes (IBP)	0.189***	0.350***	0.152***	0.160***	0.121***	0.069**	1	
8	Innovation in the firm's organization of work (IOW)	0.170***	0.260***	0.065**	0.141***	0.115***	0.062**	0.485***	1
9	Innovation in the firm's external relations (IER)	0.155***	0.166***	0.082***	0.129***	0.086***	-0.016	0.3667***	0.329***

N=1240
*p < 0.1.
**p < 0.05.
***p < 0.01.

Table 3
Moderating effects of hybrid change agents (OLS regression)

	Product innovation	Process innovation	Patents	Sales of improved products	Sales of new products
Training Firm (TF)	0.038	0.011	0.056***	0.449	0.285
Innovation in the firm's business processes (IBP)	-0.004	0.306***	-0.048	-2.362	0.657
Innovation in the firm's organization of work (IOW)	0.063	-0.052	-0.003	3.779**	1.217
Innovation in the firm's external relations (IER)	0.025	0.008	0.032	0.317	2.430
IBP * TF	0.068	-0.090	0.144***	5.443**	0.399
IOW * TF	-0.004	0.197***	-0.058	-3.256	-0.300
IER * TF	0.073	0.009	-0.031	1.973	-2.619
N	1240	1240	1240	1240	1240
Adjusted R^2	0.199	0.203	0.218	0.113	0.096

Notes: Training Firm (TF); Innovation in the firm's business processes (IBP); Innovation in the firm's organization of work (IOW); Innovation in the firm's external relations (IER). Control variables are: Firm size, workforce educational background, competition intensity, price and non-price competition, export orientation, demand expectations, technological potential of the industry, sector, region.
*$p < 0.1$.
**$p < 0.05$.
***$p < 0.01$.

Appendix

Table A.1 Comparison of estimation sample with full sample.

	Full sample Mean (n=2034)	Sample in analysis Mean (n=1240)	Mean difference
Outcomes			
Product innovation	0.441	0.431	0.010
Process innovation	0.310	0.316	-0.006
Patent applications	0.160	0.122	0.038***
Sales of improved products (in % of…)	6.501	6.670	-0.169
Sales of new products (in % of…)	5.715	5.587	0.128
Explanatory variables			
Training Firm	0.710	0.710	0.001
Innovation in the firm's business processes	0.344	0.343	0.001
Innovation in the firm's organization of work	0.345	0.335	0.011
Innovation in the firm's external relations	0.227	0.220	0.007
Controls			
Firm size	224.534	208.407	16.127
Workforce educational background (in %)			
Employees with university degree	7.824	7.963	-0.139
Employees with PET degree	17.686	18.127	-0.441
Employees. with VET degree	51.498	51.141	0.357
Employees. with other degree	23.341	23.158	0.183
Competition intensity (in %)			
Up to 5 competitors	0.270	0.288	-0.018
6-10 competitors	0.285	0.301	-0.016
11-15 competitors	0.105	0.105	0.000
16-50 competitors	0.125	0.143	-0.018
More than 50 competitors	0.146	0.151	-0.005
Price and non-price competition			
Price competition	3.922	3.969	-0.047
Non-price competition	3.031	3.018	0.013

Export			
Export orientation	0.498	0.518	-0.020
Demand			
Past demand	2.924	2.929	-0.005
Expected demand	3.028	3.031	-0.003
Technological potential			
Technological potential of industry	2.672	2.677	-0.005
Sectors (in %)			
Manufacturing	0.479	0.497	-0.018
Construction	0.082	0.092	-0.010
Services	0.440	0.411	0.028
Regions (in %)			
Lake Geneva Region	0.119	0.110	0.008
Espace Mittelland	0.210	0.215	-0.004
Northwestern Switzerland	0.125	0.131	-0.005
Zurich	0.200	0.195	0.004
Eastern Switzerland	0.184	0.193	-0.008
Central Switzerland	0.096	0.097	-0.000
Ticino	0.065	0.060	0.005

Note: Full sample has missing values in the listed variables.

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